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THE CRIMINOLOGICAL ASPECTS OF PAPER

(West Germany)

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THE CRIMINOLOGICAL ASPECTS OF PAPER

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We propose to discuss exclusively the objective manifestation and the material quality of paper. We are not concerned here whether the paper is used as sign or mark carrier (signs or marks: handwriting or typing, drawing, pictures, superposition of substances, erasure, or other mechanical action, etc.), as document carrier (including bank note paper, stock certificates, stamps, carriers, and the like), or as object sign, respectively, as object with the character of a sign, mark, or trace. (Cf. series of publications by the Federal Criminal Police Bureau, 1958, No 2, Criminological Sign Science, I, page 27.)

We are only going to take up the characteristics of paper which are so to speak "inborn" in it; that is to say, only the complex of characteristics which stems from the production of the paper (including production or processing, such as subsequent cutting to format, grooving, lining, etc.).

The characteristics which come out later, from the moment of utilization of the paper, the so-called "acquired" characteristics, must be discussed separately.

Today, life without paper would be unthinkable. It has many uses in many fields; but we can distinguish two main groups: paper

(1) as script carrier (including document carriers, etc.) and

(2) as article of industrial, commercial, and everyday use.

It is, of course, possible for the main purpose of a piece of paper to be modified or altered, but the criminological and crime investigation objectives which can be pursued with the help of a piece of paper essentially remain the same.

A paper napkin remains a paper napkin, regardless of whether it was momentarily and provisionally used as carrier of a note or a communication; similarly, a newspaper remains a newspaper, even though it may be used as wrapping paper.

But let us not forget that paper was originally invented as script carrier and that it did not assume its many forms of utilization until much later.

I. HISTORY OF PAPER DEVELOPMENT

It is worthwhile to review the history of paper in brief.

The desire to record impressions and thoughts or to transmit communications over long or short distances was probably the godfather in the development of the more or less suitable script carriers of past ages.

Via clods of clay, followed by clay tablets in which picture or script symbols were scratched in a wet or unbaked condition, we finally arrived at the real forerunners of our paper.

The Egyptians knew all about papyrus as early as 3500 B.C.; it was used first in sheet form, then in rolls [scrolls], and finally in codex form. It was made from up to 5-m long stalks of the plant by that name, whose pulp or pith, cut in long and thin strips, was stacked in two layers and in crossed fashion, and was then hammered and smoothed. This produced a flexible, thin, and comparatively resistant bright-yellow sheet which we might compare to a thin sheet of plywood.

Around the year 2000 B.C., the Egyptians came up with another script carrier: parchment. It was made from untanned skins (of various domestic animals), which were only stained, scraped, and polished and which became quite useful and durable script carriers. Parchment was used also in the West, but papyrus found hardly any use there.

In the Far East, silk was used as script carrier as early as the third century B.C. People wrote or painted on it with brush and India ink. But the Far East is the real cradle of our present-day paper, though the Egyptian name "papyrus" was applied to it later.

The Chinese court official Ts'ai Lun is named by the chroniclers as the inventor of paper (105 A.D.). But it must be assumed that Ts'ai Lin only put the finishing touches on a presumably centuries-long development process -- from silk and animal textile fibers to plant fibers -- and thus created the new script carrier which is based on separated fiber substances and on the mechanics of felting or matting; these are, by the way, principles which have remained practically the

same down to our day. We might also mention here that Ts'ai Lun's paper had as basic substance the bark of the mulberry tree and the Ramie fiber (China grass), though textile waste (rags) were also used, as has been discovered in microscopic examination of thousands of Chinese paper samples.

It is interesting to note that paper already during the ninth century of our era was used not only as script carrier but also, among others, as wrapping paper, and even as toilet paper in the empire of Harun al Rashid. A caliph of the twelfth century even issued standards for various paper formats, depending on the intended use.

This brief review might suffice. Let us now return to the present, but let us keep in mind that Gutenberg's invention and the development of the paper machine by the Frenchman Louis Robert (1799) were decisive milestones in the history of paper and made paper the important factor it is in our life today.

II. CRIMINOLOGICAL AND CRIME INVESTIGATION OBJECTIVES

Continuing along the line of this topic, we now come to the question: What are the criminological and crime detection possibilities and objectives presented by paper today?

We must commence the reply to this question with the principles of the delimitation of the objectives offered to the criminologist and the criminal detection specialist by paper. Let us note here, by the way, that it is not necessary and that it is not intended here to go into the theoretical delimitation of the concepts "criminology" and "crime detection." These interlaced boundaries in practice lead hardly to any conflicts as to respective fields of competence. It is in practice immaterial to know, for instance, where criminological sign or mark search ends and where crime-detection sign identification begins. Even within the realm of sign identification, one can often or most of the time not recognize with absolute certainty where its criminological aspect ends and where pure crime detection begins.

The following principal objectives and/or trends can be outlined from our criminological and crime-detection observation point:

1. The recognition of the type or grade of paper, its structural and chemical properties, etc., i.e. a sort of "system determination" (see note) designed to

(a) define the place or places of production (possibly also of sale) of the paper -- as a bridge to the user of the paper who interests us in the detection of a crime -- and

(b) the production time or period of the paper product in question.

([Note] "System" is a crime detection technique concept with a conventional origin that is supposed to include all those characteristics which make it possible to identify a material or an object with respect to production place, production period, peculiar manner of utilization, etc.)

2. The identification of a piece of paper (which is to become a piece of evidence), respectively, its association with a certain (local or property) origin that is in direct or indirect connection with the facts of a case, with the help of comparison material, whereby

first, the material [substance]

and second, the form component

play a mostly combined role.

3. The realization that the paper, the script, document, or stock certificate carrier, etc., has become the object of a forgery (e.g., of a chemical attack), or at least an attempt at it.

The possibilities for the attainment of these main objectives can be grouped as follows according to the complex of "inborn" characteristics.

1. According to characteristics which indicate the so-called "outward" appearance form of the paper.

2. According to the internal structure.

3. According to the material or substance qualities.

The "acquired" characteristics are to be made the subject of a separate treatise, and so should the characteristics manifestations which represent more or less transition forms to the "acquired" characteristics; here we have, first of all, additional, production-conditioned substance or material signs, as well as imprint or copying marks from production, processing, etc., and, second, original form marks.

Before we can go into this complex of questions, we should learn the most important facts about the creation of paper with respect to substance and processing. This will give us facts which can serve us as key elements in criminology and crime detection techniques.

III. THE PRODUCTION OF PAPER

The necessary and useful raw materials for paper production — basically, there are comparatively few — are the following:

rags,

wood,

straw, grasses, and

waste paper;

they are turned into the raw materials of paper through corresponding preparation and processing.

Once we have these materials, we start the fiber extraction phase which leads via the half stuff phase (beating, soaking, drying, bleaching, etc.) and the pulp phase (grinding, mixing of half stuff, filling, respectively, weighting and opaquing, glueing, dyeing, and neutralizing) to the final phase of leaf formation (through scooping by hand or on the long-sieve, round-sieve, or cardboard machine) to the production of paper.

A. The Half Stuff Phase

The fiber raw materials of the paper can be subdivided from a chemical and technical viewpoint as follows:

1. Rag fibers (rags), respectively, plant fibers of a non-lignified kind.

2. Cellulose, respectively originally lignified (plant) fibers, which are chemically converted into pure cellulose fiber.

3. Lignified fiber material which finds use also in this (lignified) condition in paper production.

Rags as Raw Material

The term rags or rag raw materials applies to fabric waste consisting of cotton, linen (flax), and hemp fibers, i.e., nonlignified plant fibers, that is to say, they originate either from the cutting waste of the textile industry or from old clothing and underwear and linens. This fiber material has once before been treated mechanically and chemically and had then been loaded with foreign substances and dirt through technical processes (finishing, impregnation, etc.) and

through actual use; it must therefore be prepared for the half-stuff phase through sorting, dusting, cleaning, cutting, boiling, washing, and bleaching.

Rag paper is a real fine-grade paper which is distinguished by its special strength and durability. It is therefore used primarily for documents, currency, and other value-bearing paper. This can be traced back to the advantages inherent in the rag fibers, which are originally pure cellulose fibers; they are very elastic, pliable, not or hardly hygroscopic, as well as easily fibrilable and feltable. For high-quality rag paper, only new, unused rag material — i.e., material from the textile industry — is used, while used goods, respectively, old rag material comes into consideration solely as additive for rag-containing paper.

According to their origin, rag fibers can be the following.

Cotton, obtained from the seed shells of that plant. But cotton-linters — especially for pure rag paper or industrial fine-grade paper — may be considered here; the linters involve a short-hair coating which remains behind on the seed surface after the removal of the actual cotton fibers.

Linen and linen fibers, consisting of the bast cells of flax.

Hemp fibers which are especially easily feltable.

Jute and manila are East Indian plant fibers consisting of bast cells which are used for the production of sacks as well as rope and cord.

But animal fibers, such as wool and silk, are also used in special cases (e.g., as mottling material).

Cellulose as Raw Material

As we indicated earlier, cellulose is made up of plant fibers which were released from their original lignification state by means of a chemical decomposition process and which were thus turned into pure cellulose fiber.

The most important source for the extraction of this raw material, respectively, of cellulose, is the timber of our forests. For long-fiber cellulose, we take evergreen wood, such as the fir, the pine, and the spruce. Short-fiber (soft) cellulose is extracted from aspen, poplar, and white poplar; if it is to be harder, it is taken from the beech. In some other countries, chestnut trees, birch trees, and eucalyptus are used for the extraction of short-fiber deciduous wood cellulose.

According to scientific findings, our domestic timber consists of (about) 50% cellulose and 50% noncellulose (30% lignin, 18% higher forms of sugar, as well as 2% resin, albumin, and ash).

In the case of timber (and straw), as in all plants, the body consists of cells surrounded by a cell membrane. While in the cotton, linen, and hemp fibers, the cell membranes remain soft and pliable, they harden in the wood fibers through the deposit of various substances (resin, bark-forming lignin, silicic acid, etc.) which are called incrusts.

Here are some more cellulose bodies which are hardly any less important.

Straw cellulose, extracted from rye and wheatstraw but only to a minor extent from barleystraw, and

esparto cellulose (esparto grass grows in Spain and North Africa).

The mechanical pretreatment of the wood (and of the other raw materials) is accomplished by hacking machines or similar devices. In the second extraction phase, we have the chemical decomposition (including washing, sorting, and, if necessary, bleaching); this is designed to destroy the incrusting components along the cell membrane and to remove them or wash them out.

Since the quality of the cellulose is determined not only by the type of raw material but also by the kind of decomposition process, we ought to mention the following essential ones:

the soda process and the sulfate process (alkaline decomposition),

the sulfite process and the nitric acid process (acidic decomposition),

and the soda-chlorine process (combined decomposition).

In the various processes of chemical decomposition, we are dealing always with boiling processes to which the raw material is subjected in special boilers, with the help of the particular boiling liquid used in the particular process (sulfurous acid, soda lye, etc.).

For the sake of completeness, let us mention here that the so-called yellow straw pulp and the straw half stuff are used as raw material of secondary quality.

The yellow straw pulp is made mostly from rye straw and wheat straw (abroad it is also made from corn straw and other grass types growing there).

Straw half stuff or semicellulpse are intermediate products between the yellow straw pulp on the one hand and the straw cellulose on the other hand. Besides, reed straw and several domestic grass types can be processed into a straw half stuff (as additive).

Mechanical Wood Pulp as Raw Material (Lignified Fiber Material)

Among the materials which are processed in the lignified state and which are called "lignified fibers," we have mainly — in addition to raw jute and yellow straw pulp — the mechanically obtained "mechanical wood pulp" (wood cellulose) from fir, spruce, and deciduous wood; here the wood is transformed and ground only with the addition of water and with the help of a grinding device (grinding stone) into a very fine wood pap which is ready for further paper production.

The "grinding of the wood" is a German invention (Keller) from the year 1843; this date is important, for it will play a role later, perhaps more frequently, in the examination of the genuineness and age of documents and the like.

While in cellulose production, the wood fibers are freed only of the undesirable incrusts (inclusions) in a chemical manner and while thus the natural fiber quality is practically retained, the extraction of mechanical wood pulp occurs through a purely mechanical force for the purpose of the (mechanical) roughening of the fiber material. In the grinding process, to be sure, the wood fiber is torn into very small parts, but, on the other hand, the resin and lignin components (in contrast to cellulose) remain in the fiber. The end result therefore is a short, brittle, and hard fiber material which is only very little feltable and which tends to become yellow soon on account of the resin and lignin content. The wood fiber alone cannot be used for the production of paper; the addition of cellulose — though in a very small quantity — is absolutely required. But certain pertinent and appropriate developments are in progress which are aimed at the additive-less, respectively, cellulose-free processing of mechanical wood pulp.

The superiority of the grinding process (in mechanical wood pulp) lies in the exploitation of the quantities available. This advantage becomes quite clear when we compare the dry substances for the two end products with each other. From 1 cu m of debarked fir wood with a weight of about 400 kg, we get, depending on the quality, 240-280 kg of absolutely dry mechanical wood pulp; in the chemical process, depending on the particular decomposition process employed, we only get about 120-145 kg of absolutely dry cellulose.

Depending on the structural characteristics and depending on the manner of production of the wood cellulose, we are dealing either with white ground wood or brown ground wood.

To produce the white mechanical wood pulp, the dried roll timber is sawed into disks and then ground on grindstones into a very fine wood pap under mechanical or hydraulic pressure. In addition, we distinguish between a coarse mechanical pulp (coarse mechanical pulp) and a smeary hot mechanical pulp (fine mechanical pulp), depending on the desired grade of feltability.

In spite of its structural characteristics (short, brittle, and hard fiber), which in most cases soon leads to the friability of the paper, and despite its great susceptibility to yellowing, it is nevertheless being used on a large scale for the fabrication of ordinary paper (e.g., newsprint).

The brown mechanical wood pulp is made exclusively from pine wood, which however is boiled prior to grinding; this causes the partial solution of the incrusts of the plant fibers and the cohesion of the cells is loosened; we thus find a certain chemical change in the wood. Therefore the brown mechanical wood pulp should be considered as an intermediate stage between the white mechanical wood pulp and the cellulose.

<u>Old Waste Paper as Raw Material</u>

In the beginning, we also mentioned old waste paper as an important basic material for paper production; let us recall this point here, although waste paper was essentially included as raw material or half stuff in the preceding statements on this subject.

Old waste paper is very important as reused raw material and — at least in the form of an additive to the new paper or to cardboard — it helps make up the desirable utilization cycle of this material.

This raw material is all the more valuable, the better, respectively, the more uniform it is sorted out. Of course, blank unprinted, white, or single-color, wood-cellulose-free kinds of old waste paper are better for processing purposes. Therefore, waste coming directly from paper production is the best old paper, for it is completely clean and homogeneous in its composition.

In this connection, it would seem to be of general interest to list the trade terminology of the most important waste paper types.

Mixed paper and cardboard waste
Corrugated cardboard waste
Print shop waste
Old newspapers
Picture magazines
New newspapers
Bright (colored) bookbinding chips
Leather-cardboard waste
Old soda-paper bags
Dark hemp
Bright hemp
Original document paper (including, colored document paper)
White bond paper (a) assorted
(b) free of clamps, wires, and threads
Letter envelope chips
(subdivided according to certain assortment categories)
Heavy-duty paper cuttings or waste (e.g., paper bags)
White cellular pasteboard waste
Wood-containing white chips
Wood-free white chips
Hollerith carton
Business ledgers, no covers or registers, no wood content
Synthetic paper waste
Looseleaf fillers
Manila carton
Tickertape
Phone directories
Colored paper
Wall paper
Used weaving and spinning spindles

This, essentially, is the half stuff phase of paper production in outline.

B. The Pulp Phase

The degree of decomposition and of bleaching, the structural peculiarities of the individual fiber materials, etc., are of great importance to the paper to be produced. The half stuff materials are therefore selected accordingly and are either ground in a certain percentage ratio in the pulp beater or separately in several pulp beaters. The separate grinding has the advantage that every fiber can be ground in accordance with its peculiar characteristics.

In the production process discussed hitherto, the half stuff materials are not yet sufficiently broken down to reveal the degree of fineness commensurate for proper felting. They must be subjected to

further crushing, grinding, and mixing, and to glueing, filling, and dyeing in order to become "pulp" in the end and to be ready in this form for the final phase of sheet or paper web formation.

The various half stuff materials mostly come in the form of bales or rolls and must be chopped up in advance by special machines (tearing machine, defibering machines, edge or pug mills, etc.).

One "pulp beater" usually can hold 100-600 kg of material. The grinding is done in a trough (with an oval ground plan), in which the material is made to circulate by means of separation and guidance walls. We have single-channel and double-channel pulp beaters equipped with stone grinding tools or steel or bronze knives. The grinding material gets between the rotating, knife-studded roller and the beater plate (a bunch of fixed knives) and is chopped up gingerly by the scissors effect of the knives of the roller and of the beater plate.

The various grinding grades can be obtained by varying the interval between the knives of the roller and those of the beater plate; the range extends from actual cutting up (scissors effect) all the way to the squashing of the fiber, i.e., from "coarse" to "smeary" grinding. These two grinding grades are further subdivided into "short" and "long."

In keeping with modern industrial practices, paper fabrication has been completely mechanized. There was hardly any room left for the oldtime papermaker; nevertheless, even today every fine-grade paper factory must depend on the pulp beater operator and his personal individual knowledge, since thicker or thinner material furnish, changes in the adjustment of the grinding tools, and coordination of the grinding time are of decisive importance.

A paper consisting of coarsely-ground material is soft, woolly, and absorbent, and has little strength; it hardly has any "tone" (e.g., blotters or filter paper).

Smeary grindings produce a glassy-transparent, very strong, and good-gripping paper (e.g., pergamin paper). Long and squashed fibers produce a paper with clouded transparence and great strength.

The most used grinding grades are coarse long and smeary short. Medium grinding grades are preferred for writing and printing paper.

The grinding and the material mixing are of utmost importance in paper production, for they give the paper the desired qualities and its peculiar character.

But the auxiliary materials of paper production, i.e., the glueing, filling, and dyeing materials, exercise hardly any less influence on the character and useability of the paper.

The Glueing of the Material

For the moment, the paper material is still a wattlework having many pores and consisting of individual fibers which can absorb and soak up all liquids, so that this paper behaves like a sponge. But this quality is required only in blotting and filter paper and in other absorbent paper, in vulcanized fiber and parchment raw materials. The requirement for most of the paper types is that the liquids placed on their surface remain preserved in a sharply delineated form. This is attained through the glueing of the paper, a process in which the paper is made resistant against the penetration of liquid to the desired degree; this quality is called the "bonding strength."

An epochal invention in this field was that of papermaker Illig of Erbach in Oden Forest, who in 1806 replaced animal glue with resin (tree resin) and alum.

The art of glueing the paper consists in so mixing the material mass with the resin or resin milk that the fibers are completely enveloped, without however even partly losing their feltability as a result; rather, the consistency and cohesion of the fiber mass must be improved.

The process of introducing the resin glue into the material mass and to glue it is generally called "vegetal" glueing. In contrast to this, the glueing of the surface of ready paper by means of an animal glue solution is called "animal" glueing.

Thus we see that there is such a thing as material glueing and something else again called surface glueing. We might also mention here that the resin glue alone does not suffice to give us certain qualities of paper. It must therefore be given such additive as

animal glue, which improves the strength, hardness, and erasure resistance of the paper, which means that one can attain the desired erasure sensitivity of a paper in certain cases by means of a corresponding trick;

starch, which gives the paper what the paper expert calls "grip" and "tone";

wax glues, which are intended to promote the surface consistency and flat-lying characteristic of the paper;

water glass, for the improving of the hardness and smoothness of the paper;

paraffin glue (in the form of emulsions) with the addition of casein, among others, which makes the paper softer and more water-repellent;

artificial resins for greater moisture-resistance of the paper, etc.

The Filling of the Material

Fillers have the following tasks: to fill the gaps between the fibers, respectively, the pores of the paper and to assure a smooth surface; to make the paper heavy; to improve its quality, to make it more opaque, and/or to reduce its transparency to a useful degree; to make it soft and pliable for particular printing purposes; to give the paper a pure white color; to improve the smoothness of the paper, respectively, the glazing; to fill certain types of paper so much that they will have a certain flaccidity and noiselessness (paper for programs); to regulate the combustibility of the paper, e.g., cigarette paper; to adjust the weight of the paper and partly also to make the paper less expensive, since most fillers are a lot cheaper than the fiber materials. (Here it must be noted that a part of the fillers runs off with the waste water.)

The enumeration above shows that the quantity and quality of the fillers also determine the utilization and quality of the paper. For this reason, it would seem to be a good idea here to list the fillers that come into consideration.

(a) Silicates:

aluminum silicate, alumina with silicic acid (kaolin, porcelain clay, china clay)

magnesium silicate, magnesia with silicic acid (talcum)

magnesium-calcium-silicate (asbestine)

(b) Sulfates:

calcium sulfate, sulfate of lime (gypsum fillers)

crystal-water-containing calcium sulfate (brilliant white or ground gypsum satin white)

crystal-water-free calcium sulfate (annaline)

barium sulfate, sulfate of baryte (heavy spar, blanc fixe or permanent white)

(c) Carbonates (carbonate of salts):

magnesium carbonate, carbonate of magnesia (magnesite)

(d) Oxides (metal-oxygen combinations):

titanium white (titanium oxide, mixtures of titanium oxide and blanc fixe).

Let us note here that the quantity of the mineral substance remaining in the paper material is expressed by the ash content of the paper; we shall come back to this later.

It is probably clear by now what tremendous number of variations and variants is made possible by the fillers and what conclusions can be drawn from this.

The Dyeing of the Material

Most paper types contain dyestuff additives in one form or another; these substances are added to give the paper a light tone or a deeper color. This is one of the most difficult jobs in papermaking.

The coloring of the paper is coordinated with its utilization purpose and the dyestuff is so selected that it will be adjusted to the composition of the paper material and that it will meet the requirement for genuineness (bleaching resistance, alkali resistance, acid resistance, chlorine resistance, water and steam resistance, lacquer and veneer resistance, rubbing resistance, and heat resistance).

The degree of whiteness of the paper is increased through dyeing with soluble blue, red, or violet dyes or with pigments (Indanthren) or ultramarine. These dyestuffs compensate for the yellow component of the paper material; this results in a grey color which looks better to the human eye than the yellow tone.

Through the addition to optical white tone (blancophores) -- so-called fluorescence bodies -- bleached paper materials can be considerably brightened.

The acidic dyes, which are more customary for the dyeing of the mass, are: tar dyes (analin dyes) and inorganic dyes (mineral dyes).

C. The Final Phase

Now the pulp itself is ready; we have the "tub-ready" material which is now to be moved to the sheet formation phase.

Sheet formation is accomplished through "scooping with the hand" or by machine.

One might think that this age of technology of ours would have no room any more for hand scooping. But that is not the case since even today a few paper factories produce genuine, hand-scooped paper in a similar, though improved, manner, compared to the old hand papermakers prior to the invention of the paper machine. In view of the small role played by hand-scooped paper today, we shall discuss this manner of production very briefly. One must not forget that hand-scooped tub paper even today represents the best, most durable, and noblest in the paper industry. From a tub in which we find the correspondingly prepared pulp, sheet after sheet is scooped out by hand with a hand scoop form (drum) — just as in the old days — and is then air-dried. This tub paper has the characteristic (rough) deckled edge, which is conditioned by the scooping work and the scooping frame. But this kind of paper can also be made by machine, respectively, with the tub sifting drum machine. These products can hardly be told apart from the really hand-scooped tub papers.

Let us just mention here that a hand-scooped tub paper, of course, cannot have the complete planing of the surface and the uniformity of a machine-made paper; both of these qualities are desired especially by the printer; on the other hand, its quality is better than that of all other paper types, as we said before.

And now let us take a look at the paper machine, to be more specific, primarily the Fourdrinier.

In a very short time — just about one minute — this machine does a job that borders on a miracle; from a thin pap consisting of 98% water it makes the finished paper.

The term paper machine denotes a connected and coordinated installation (which can be up to 120 m long) consisting of various items of machinery; it makes possible the uninterrupted production of paper in a continuous operating procedure. The operation of such a machine would seem to be of interest also within the scope of this treatise; we shall therefore describe it briefly in principle.

The tub-ready material for paper production is moved from the mixing pulp beater to the machine tub or the stirring tub which at the same time is a storage container. From here, the material is moved for instance by means of a scoop mechanism into the material mixing box for thinning with return water from the paper machine.

The material and water mixture, whose density and quantity is very important, is then fed into the "material catcher" and the "sand catcher" in order to give us the thick material and to eliminate all heavy and sandy components.

Then the "knot catcher" goes into action; there, all coarse and knot-forming fibers are removed from the material.

After it leaves the knot catcher, the material flows via the material forward end, which consists of format cart and grating boards, to the drum [sieve]. The grating boards are intended to regulate the onflow speed of the material which must be adjusted to the operating speed.

The sieve of a paper machine is woven of fine bronze wires and moves continuously over two parallel rollers which are situated on the same level (the breast roller and the suction, respectively, couch roller). The length of the sieve is determined by the particular functions to be performed and may amount to 15-32 m. The paper sheets are formed on the sieve which is limited right and left by rib flanges. This sieve furthermore performs a lateral vibrating or shaking motion which is intended to assure a later felting of the fibers and a better, respectively, homogeneous transparency of the paper as the paper material glides forward.

The first half of the sieve is carried by the so-called register rollers which serve for the drainage of the paper material. They are followed by the so-called suction rollers, which are intended further to drive the gears of the register rollers by means of underpressure.

Inside the suction part, we have the paper blank or egoutteur [draining] roller which is covered with a bronze wire mesh. This draining roller is supposed to level off the irregularities in the surface of the paper web and further to improve the transparency. But this roller serves also for the production of water marks, if desired. On this roller we attach the desired figures, marks, or letters, which are then impressed into the moist sheet of paper, which make the paper thinner in these places, and which let the water mark shine through.

Then the paper web runs over the suction or couch roller; further drained and solidified, the paper web is guided from the sieve to the wet press, where the water content of the paper material is further reduced.

The so-called offset press smoothes the paper surface in the (still) plastic condition and conducts the paper web into the drying part in which the rest of the excess water evaporates (with the help of steam-heated drying cylinders). Then the water finish sets in the paper which has been predried to about 80%, if "keen" machine finish is desired instead of a normal finish.

Sometimes additional devices are built into the drying part in order to facilitate onesided finish, animal surface glueing, coloring of the interior side of cheap letter envelopes, application of a coating mass (as binding agent), etc.

Upon leaving the drying part, the paper web is greatly heated and also electrically charged; it must therefore be conducted around one or more cooling cylinders. Then comes finishing by means of a dry finishing device, consisting of stacked-up polished chilled rollers. In some cases we finally have also a longitudinal cutter, which trims the two paper web edges and which cuts up the paper web into certain definite widths.

Then comes the reeling phase.

Paper types which are to be satin-finished or glossy, are also placed in a roller calender whose rollers (up to 16 of them) alternately consist of highly-polished steel and calender paper. To obtain high-gloss paper, we have calenders "with friction."

The machine-finish and satin-finish paper types, which are not reeled up, must be cut into sheets of certain length and width. Then the sheets are sorted, counted, packed, and routed to the shipping department.

In the preparation of certain products of the paper industry — e.g., multilayer paper, pasteboard, and carton — we use sifting drum machines, as well as a combination of endless wire drum and sifting drum machines.

In the case of the sifting drum machine, the formation of the individual paper webs occurs in the sifting drums located in the material box. A joint felt device picks up the thin paper webs from the sifting drum and couches them into a multilayer paper web. In this manner, one can take qualitatively inferior material for the inner layers and better material for the outer layers; this is being done for instance in the production of duplex or triplex carton. At times, the better covering layers, which may also be colored, are produced on endless wire drums, while the inlays can be made on sifting drums.

Multilayer papers, cardboard, and cartons can also be made out of several layers of ready paper, through glueing together on special machines; these are so-called "backed" paper types.

There are many other processes for the refining of paper and for the production of certain special types of paper, e.g.,

embossed, pockmarked, and hammered [peened] paper (pattern and linen embossing),

cloth-centered paper, straw materials with glued-on narrow- and wide-meshed textile fabrics,

effect paper [effekt papiere] (colored patterns),

colored paper (grained, veined, and metal paper),

enamel paper (high-quality art paper),

impregnated paper (wax and paraffin paper),

industrial fine-grade paper (for drafting purposes),

photo paper, and

parchment paper (pergamin and vegetable parchment paper).

Our statements so far have shown the large number of elements and components offered by paper both with respect to materials and to production techniques. From this large number we can get pointers as to place and time of production, identity with a comparison paper, etc., as well as criminological and crime detection elements.

The requirements which the papermaker seeks to meet in order to accomodate the utilization purpose and the desires of the customer include more or less those requirements which we must set up in order to protect a particular type of paper against imitation or forgery (with respect to the contents of the paper in the form of documentary and value significance). A preventive protection of the paper -- from the material or production angle -- thus is imperative, in the manner in which it is conditioned by material and production techniques.

But we would fall short of the objectives we have set ourselves here if we were not to go into the types of paper which are specially produced with a view of preventive protection and whose utilization purpose requires a certain productional protection technique.

IV. PRODUCTION OF CHECK PAPER

Protection against forgery or unauthorized imitation of bank notes and other carriers of values and/or stamps, but also of identity papers (passports, identity cards, etc.) requires -- from the viewpoint pf purposeful prevention -- the production and use of so-called "check paper" [safety paper] which in addition is intended to protect the mentioned objects against forgery, regardless of whether we are dealing here with identity papers, other documents, checks, bills, etc.

To meet this requirement -- for check or safety paper -- we have many possibilities today, both with respect to material and to production methods, quite apart from the use of code symbols. Let us briefly discuss the most important of these possibilities. We can group them in accordance with their use and effect.

1. Production Safety Measures

(a) The most obvious possibility here lies, of course, in the fact that the choice, combination, and component ratio of the fiber raw materials has certain leeway possibilities which can give us the foundation for the process of security protection. In particular, we must think here of the quantitatively and qualitatively coordinated admixture of types of fiber materials that occur rarely and that are therefore hard to obtain and very expensive to buy. In this manner, we can set up the first, and at times the insurmountable obstacle in the path of the forger.

The same applies on an even larger scale to the auxiliary materials and especially to fillers. Their multiplicity, which we have already described, and the almost countless combination possibilities stamp them as a very important security factor.

But the glue and the glueing process may also enter the picture in this complex of safety measures.

(b) The so-called embeddings constitute a further safety possibility; these are foreign bodies worked into the paper material and/or into the paper web, i.e., components that are foreign to the material, such as: textile or metal threads (and strips), colored paper chips (possibly provided with microscript), stencilled colored paper chips and specially prepared mottling fibers, e.g., single-color wool fibers or a mixture of wool fibers of varying colors or hues. In this case, we speak of a "mass mottling." But there is also such a thing as "surface mottling"; in this case the material web is strewn with one, two, or more types of mottling fibers. This safety measure likewise provides good protection. The various mottling fibers may have the same

hue, but, due to the coloring with chemically differing dyes, they produce quite different reactions when certain agents are applied or they will also fluoresce differently (under ultraviolet light).

Besides, one can heap up these fibers in certain areas in the paper web. In this case we speak of "localized" mottling fibers.

But there are also processes according to which the embedding material is inserted between two couched-together full-cover webs; or it is placed in a middle web which alone contains the embeddings.

(c) The insertion of the water mark into the paper is one of the oldest safety measures, though initially it was intended only to safeguard the recognition of origin and thus constituted mostly a quality index.

Unfortunately, the water mark -- whose value must by no means be underestimated -- is nevertheless being assigned too great importance as security factor. We must not overestimate the significance of the water mark, for it too can be imitated or simulated.

Production-wise, we distinguish between

genuine (natural) and

artificial water marks.

The genuine water mark is organically tied in with the sheet formation. If it is worked into the finished paper later on, it is an artificial water mark.

In the scoop form which serves for the preparation of hand-scooped tub paper -- and on the sifting drum machine -- the genuine water mark develops already in the material water. The signs or symbols, soldered onto the sieve in relief or embossed in depressed form on the metal cloth, from the very outset effect a corresponding thickness and density in the deposit of the material fibers in these places; in this manner we get particularly clear water marks.

In case of raised embossing of signs (on the metal cloth of the machine), we get a material displacement and hence a bright spot in the paper (bright water mark) on account of the paper being thinner here. In the case of impressed embossing, larger material quantities collect in the area of the pictures, which gives us a darkened portion in the paper as we look through it (dark water mark).

In the representation of so-called head marks, preference is being given to so-called "shaded" (plastic) water marks, because here the interplay between bright and dark and between light and shadow comes out effectively. Such water marks are very hard to make and the fineness of their finish, with all its nuances of shading, has artistic value. Here we must therefore watch out not only for the outlines but also especially for the shading effects.

The operating procedure of the longitudinal sieve machine, with its endless vellum sieve which is exposed to great bending, does not give us water marks in the way we get them in the case of hand scooping or from the sifting drum machine. Here the wire structure, which is supposed to bring about the water mark, is attached to the pattern or draining roller. The water mark is thus imprinted on the longitudinal drum machine from above (outside) into the still wet paperweb.

The difference is probably clear by now: in the first case, the water mark grows organically with the sheet formation; in the other instance, it is impressed into the almost finished paper sheet — still during the wet phase. It is probably likewise clear that such a water mark cannot reveal the same clarity and sharpness as the first-mentioned.

On the other hand, the artificial water marks reveal a noticeable precision. These marks are today being used on a not inconsiderable scale and are subsequently either impressed into the finished, dry paper or they are produced by means of color or bold-face print. In the former case, this is done with the help of so-called embossing calendars which emboss the water mark on the ready, dry paper through purely mechanical pressure (grey mark).

The ready paper sheets can also be inserted between so-called embossing plates and be subjected to the corresponding pressure in a roller press or in a calender, i.e., in a plate calender or in a press, which then gives us the "impressed" water mark.

But, as we said before, we can also use color or bold-face print in order to give the paper increased transparency in these places and to cause the paper to create a water-mark-like effect for the eye as a result of the incident light, i.e., we can get the effect of a bright water mark.

In summary, we can say the following about the "artificial" water mark. Depending on the manner of production, we speak of

color- or bold-face-print water marks and

embossed water marks.

The so-called grooved-roller water mark is something in between the genuine and the artificial water mark. It is, of course, also produced on the paper machine, though not on the sieve, respectively, in the sieve part with the help of a water mark roller, but at the end of the wet part -- however, before we get to the drying part. Small rubber rollers, which have the particular sign on their casing in relief form, are pressed against the paper with corresponding (light) pressure; of course, we also have a counterpressure roller here. Into the still moist and hence moldable paper web we can impress the particular sign, without however -- as in the genuine water mark -- displacing the fibers laterally, for these fibers are strongly fixed in position on account of the felting and can therefore only be pressed together. The grooved-roller water mark has the advantage that it is cheap; water mark draining rollers on the other hand are very expensive propositions.

2. Safety Measures with an Optical-Physical Effect

As far as the technique of paper protection is concerned, it is above all the ultraviolet rays that have assumed great significance because they can bring about characteristic fluorescence phenomena in certain substances or bodies. For instance, auramine, rhodamine, brilliant dianil green G, uranine dyes, and blancophores and lumogenes are distinguished by especially noticeable fluorescence colors. The marking of genuineness by means of fluorescent chemicals is basically a latent form of protection, because, e.g., fibers (substantively) dyed with a blancophore remain colorless in daylight, whereas they luminesce and/or fluoresce strongly in a red-violet, blue-violet, and blue-green manner under ultraviolet light. We can, of course, also substantively dye mottling fibers with these blancophores, which can be spotted in their noticeable and characteristic fluorescence only if we use an analysis quartz lamp. Varyingly colored and varyingly fluorescing mottling fibers would give us increased protection against forgeries.

3. Chemically Acting Safety Measures

Chemical genuineness guarantee consists in working (into the paper) those visible or invisible substances (indicators) which are caused to produce specific color reactions or some other easily determined reaction with the help of certain substances or chemicals (detectors). Such a color reaction is the recognition sign for the genuineness of the paper.

Many reactions of analytical, organic, and inorganic chemistry (more specifically, of dyestuff chemistry) -- selected according to the degree of difficulty of their identification possibility by means of chemical

and physical examination on the part of the forger — are suitable for chemical protection measures. The less known and available these means are, and the more difficult their chemical analysis is, the greater is their value in the assurance of genuineness.

Let us just discuss the most important of the many possibilities of chemical paper protection through coloring in the calender with reactive dyestuffs by means of impregnation of the paper mass with organic or inorganic agents, e.g., with metallic salts, or through combinations of the two just mentioned protection methods.

The coloring of the paper by means of reagence or indicator colors has proved to be very effective. The reagence colors show only in combination with the control substance whether we are dealing with the protection dye in question or not.

In experiments aimed at producing changes in writing, overprints, etc., on the paper with the help of chemical agents, the indicator colors immediately lead to color reactions or discoloring which unmask such attempts. The homogeneous distribution of uncolored substances of small grain size within the paper material or on the surface of the paper is therefore of special value because these materials, on the basis of their special material qualities, form an extremely resistant dyestuff visavis chemical agents, such as, for instance, visavis liquid eradicators, as soon as they come into contact with chemically active substances.

In this connection we ought to mention that we can today produce latent color prints which, for instance, during an attempt involving chemical eradication, react with the so-to-speak automatic development of colored printed characters.

Let us briefly mention in their essential outline the very definite qualities of a chemical and physical nature which must be present in the forgery indicators.

(a) The indicator substance must be neither volatile nor sublimable at ordinary temperature.

(b) The indicator must be protected against atmospheric influences (light, air, carbon dioxide in the air, air humidity, etc.) as much as possible. This is quite natural, for otherwise the occurring changes would cause undue suspicion of forgery.

(c) The substance must be as odorless as possible.

(d) The forgery indicator must be nonpoisonous or at any rate, it must not be poisonous to a dangerous degree.

(e) The forgery indicator must not clash with the paper substance (and with the printing dye) and it must not have any qualities that are unsuited for the paper substance.

(f) The color indicator should come in a very small quantity and should at the same time operate very intensively and indicate the color change very quickly.

(g) The just-mentioned color change of the (primary) indicator must not be capable of being destroyed by any chemical or physical agent. In many cases, this requirement can be attained only with the help of the secondary indicator -- which protects against such a color change or reversal or against such a destruction of the indicator color that has become visible -- through reaction in the second phase of the forgery attack.

(h) Both the primary and the secondary color indicators must take effect on the paper as deeply as possible, so that they cannot be removed, for instance, through erasure.

(i) In order to prevent the forger from extracting the indicator prior to his forgery manipulations, the indicator, following its penetration into the paper, must be insoluble in all organic or inorganic solvents or must become insoluble under the effect of light or air (or also of chemicals).

(k) In case the color of the forgery indicator itself is visible -- the invisible ones are of course to be preferred -- a marked color difference between the indicator's own color and the reaction color must be assured.

(l) The forgery indicator should, of course, not make the safety paper very much more expensive, but it must be hard to get or impossible to obtain commercially. The forger would therefore have to be forced to synthesize it first. The most suitable substances would seem to be those which could be invented for this purpose for the particular special case. For under this assumption the forger would first have to extract these substances from the paper in sufficient quantity and/or isolate it, in order then to subject it to a time-consuming and highly expensive analysis and component determination. But even that does not give the forger what he really wants, for he has still not determined the manner and form of synthesis of the substance.

(m) The reaction range of the forgery indicators should be as wide as possible and should include oxidation agents (hypochlorites, permanganates, etc.), reduction agents (hydrosulfites, sulfites, etc.), acids (acidic oxalates, etc.), alkalies (soda lye), etc. Now, of course, this requirement is extremely hard to meet if we consider, e.g., that a solvent indicator in most cases cannot be insoluble. Here we can often get help in the form of the previously mentioned secondary indicators.

The term forgery indicators includes all those substances which not only indicate a chemical forgery attempt, but which also prevent the forger from succeeding in such an attempt. Thus, the term forgery indicator also includes oxidation, bleaching, and etching medium indicators.

The previously-mentioned surface coloring ought to receive special consideration in this connection (i.e., in connection with paper safe-guarding possibilities). The color application in this case results only in a thinly-dyed surface layer, while the mass of the paper remains uncolored. Such papers furthermore offer a not inconsiderable protection against mechanical and also against chemical attack. An especially interesting variant on this can be obtained by running the paper through a so-called Dessinier [punching] machine, after dyeing and rinsing; this machine does not apply a colored pattern but merely exerts blind pressure on the paper. In this manner, we get patterns on the paper which coincide on both sides of the paper.

This safeguard method at the same time leads to the (already mentioned) codified designation, respectively, protection; here the selection or adjustment of the cutting phase is handled in a certain relationship to the blind pressure design.

For the sake of completeness, let us state here that a code designation consists not only in a certain codification of the designation but also in the place where this designation can be found. It must be very hard to find.

In summary, we can say the following on the safeguarding problem. The genuineness protection features must on the one hand make imitation attempts extremely difficult, and on the other hand facilitate a relatively easy, undisputed, and clear recognition.

If we consider the practical effects of this principle in connection with the discussed protection possibilities, we find that the genuineness-indicating qualities of a value or document paper could perhaps also be grouped depending on whether these qualities can be grasped directly -- i.e., with the five sensory organs -- or whether they can

be made visible or recognizable only indirectly with the help of instruments or chemical means (and methods). We shall come back to this later.

We have shown so far which methods and possibilities are given from the material and production angle, in order to protect a paper against imitation (and forgery), i.e., in order to produce a good safety paper; in this effort, we also indicated the material, time, and effort to be expended in obtaining a complete forgery and also in eliminating forgery traces.

V. INVESTIGATION METHODS AND MEANS FOR THE DETERMINATION OF KEY ELEMENTS

On the basis of our statements made hitherto and the information obtained from them, we are now in a position to discuss the possibilities and investigation methods which are useful in the recognition of those characteristic features which can point to the genuineness or falsity of a paper and, on that paper, to the forging of the script, symbols, etc. (let us recall at this point the objectives outlined earlier).

The available investigation methods might be subdivided into

(a) chemical,

(b) physicochemical, and

(c) purely physical (including optical) methods.

Of course, in practice, one will often, if not always, use combined procedures.

Earlier, we spoke of directly and indirectly identifiable marks; it would therefore be obvious for us now to want to try to describe not only the recognition possibilities of the crime detection expert but on this occasion also to discuss the recognition possibilities available to the person who is not such an expert.

The crime laboratory examination of a paper includes the following.

(1) External and

(2) internal properties (of a structural character), as well as the

(3) material composition of the paper.

The first group (of the external properties) includes the following.

(a) Paper Format

It is probably not necessary to explain this. Let us just recall the possibility that a certain special format can in itself already point to a certain source. But the format might also betray the original utilization purpose and this gives us a clue for further criminal investigation. Of course, one must not accept an unusual format without further ado -- and this is a special warning to the layman. Rather, one must examine most exactly whether it did not come about as a result of subsequent trimming and cutting.

(b) Thickness of the Paper (at times also: Strength of Paper)

It is often possible to "feel" differing thicknesses as a result of mere "touch." In other cases a measuring accuracy of 1/100 mm suffices, such as we can get it with the customary micrometer screws. But equally often we also need precision instruments, which give us measurement accuracies of 1/1,000 mm, and which can be found only in a properly equipped laboratory.

Of course, one does not absolutely have to be a crime detection expert to measure the thickness of paper.

(c) Weight of the Paper

The calculation of the weight per square meter or per sheet is used by the crime detection expert practically only in a so-called system identification. Usually, only a relative determination is necessary, i.e., the determination of the comparative weights of two equally large pieces of paper.

(d) Daylight Color of Paper

Here the main factor is the skill, or rather the color identification skill, of the human eye. But the eye will not always suffice to discover the finest nuances; often suitable equipment and crime detection experts trained in its use will have to be employed. Differences which not even an eye trained for color identification can spot can be pinned down with highest accuracy for instance by a curve diagram recorded by such a piece of equipment.

In this connection, let us recall that artificial light is not equivalent to daylight and that the effect of daylight is greatly dependent on diverse factors, such as time of day, sun, overcast sky, etc.

We must not forget that the white of a paper is dictated by its white content and that the latter (by the way, in any undyed paper) can be determined by the expert only with special aids available in a special laboratory; this, by the way, is a very important task.

(e) Surface Conformation

The latter can be very manifold; here we need to think only of the roughness, smoothness, degree of smoothness, etc. Coarser conformation characteristics can in most cases be felt by the palm of the hand or by the finger tips. Paper experts in time acquire astonishing skill in feeling even very fine differences. But these subjective methods in crime detection technique give way to physical devices which are extremely sensitive and incontrovertible and/or objective. They concern first of all,

paper smoothness, and then,

paper gloss.

Coarser smoothness values can be detected also with our sense of touch; but finer values can be determined only with special equipment. One of these devices works in the following manner. The smoothness value corresponds to the time in which 10 ccm of air at an under-pressure of 1/2 atm are sucked through between the surface to be tested and a highly polished metal or glass surface pressed against it.

Of course, the eye can in many cases spot differences in the gloss effect, especially if these differences are crasser; but a satisfactory and definitive determination can be made only with a physical device.

(f) Impurities in the Paper (due to production)

The latter can be:

splinter, sand, or mica, as well as

dirt and stain formations.

Here we ought to mention that an untrained eye will easily make errors precisely because these impurities are easily confused with embeddings coming from preventive paper protection techniques.

The second group (of internal properties) includes the following.

(a) Elasticity and

(b) tearing strength.

The examination procedures for the determination of these two properties can be conducted only with devices specially built for this purpose. Here, a certain role is being played by a prior fiber direction, respectively, grain direction identification (let us just recall the paper web on the screening machine). Let us also remember that the grain direction of the paper is also of considerable importance to the printer. Of course, the fiber direction and the grain direction can be determined without any special aids, whereas the tearing strength cannot be so determined.

(c) Folding Resistance

This factor can be determined only with special equipment. Its significance lies mainly in the sector of the user. But the crime detection expert can also gain certain comparison values from it.

(d) Bending Resistance

A paper strip of specific length and width is so hooked up in a corresponding holding device that it forms a semicircle (like an arch of a bridge). By means of a scale, the radius of this semicircle is then reduced (pressed together) to a certain dimension. The weights, which are needed to apply this pressure, give us the comparison value.

(e) Transparency of the Paper

To a certain extent, and if we confine ourselves to coarse comparison values, we can do this without special aids; otherwise, this must be done photoelectrically with the help of a selenium cell and a special galvanometer, or also with the help of a spectrophotometer.

(f) Structure of Paper Mass (in Translucency Test)

For this we need a suitable light source and, if necessary, also corresponding magnifying glasses.

In many types of paper, one can recognize the sieve pattern and the water mark, if any. But it will probably have to be left to the trained crime detection expert to tell us whether we have a genuine or an artificial water mark. Let us say once again, though, at this point that we must distinguish also in the case of genuine water marks whether it had been "scooped" on the sieve or whether it had been "impressed" by the drainer; the last named marks reveal a relatively stronger embossing and sharper contours.

For the differentiation of genuine and artificial water marks, we have a few quite simple methods which we might almost call trick methods; but they mostly result in the destruction of the water mark and hence are only of limited usefulness in crime detection.

In most cases it will be hardly of any importance in crime detection to find out whether the water mark is "genuine" or "artificial"; rather, we will want to know whether the water mark was imitated. Here we ought to remember especially that the word "genuine" in this context is a purely trade or production-technique term and that it is not used in the sense of its authenticity; one could also speak of a "natural" water mark, but this term is less used. A "genuine" water mark of authentic character might have been imitated by means of a "genuine" water mark which however is not of authentic origin. In that case it is false even though it is a "genuine" water mark.

The layman will also find it difficult to identify a water mark as grooved-roller water mark.

On the other hand, the "artificial" water marks made by means of color or bold-face print can be recognized relatively easily, though not always. The proper viewing angle and the proper light incidence can enable us to see, for instance, the overprint in a hardly noticeable grey which looks like a dark water mark during translucency inspection.

The bold-face print can be recognized even more easily since the latter gives off a glare when the light incides properly. It will therefore be relatively easy also for the layman to spot a "genuine" water mark simulated by means of bold-face overprint.

As for the simulation of a "genuine" water mark by means of color overprint, it must be mentioned that many a graphic artist or painter has been able to paint a water mark on with water colors (white and grey hues) so skillfully that it was practically invisible during inspection top-view, whereas upon translucency examination it gave a bafflingly clear "shaded" water mark -- e.g., the picture of a head. But, as we said before, one can discover the almost latently applied colors.

Other forgers have tried to simulate a water mark by thinning out the paper in places through erasing, scraping, or chipping, so that the translucency examination would create the impression of a water mark. Under the microscope, especially under the stereomicroscope, such manipulations and their consequences can easily be spotted.

Here is another manner of simulating a water mark.

The paper to be used for the forgery is so selected that it corresponds to the original to be imitated in all its characteristics, except thickness. But it is only half as thick and instead of one sheet the forger needs two. On one sheet he paints or prints the water mark sample, for instance in a light grey hue. Then he glues the second sheet over this and in this manner gets a "couched" sheet whose couching character cannot easily be spotted if the job is well done. But the surface of this (couched) paper does not reveal anything suspicious since the print (or the painting) simulating the water mark lies inside -- in the paper -- and since, upon examination under permeating light, one actually thinks one sees a real water mark.

In case of thicker or harder papers which were couched together, one might perhaps be able to perform a provisional identification of the couching character with the help of a good magnifying glass; in case of thinner or soft papers, the layman will often run into great difficulties. In such cases, the often used chipping attempts are especially notorious.

Here we ought to mention also the protective "embeddings" which one can see in permeating light, though they are mostly visible also during top illumination from vertical light sources; they thus belong to the peculiarities of the structure of the particular paper.

Deep or deeper lying embeddings -- e.g., a textile thread -- can also be imitated with the help of an ad hoc couched paper. Embeddings which are more on the surface of the paper can be simulated through overprint, painting on, etc. But it also happens that such embeddings -- e.g., threads, fibers (mottling fibers), chips, flakes, etc. -- were glued on. Such forgeries are relatively easy to spot; even a good magnifying glass may suffice to give us some clear indications. But an overprinted mottling fiber can also be quickly identified as such, for an embedded fiber can be lifted out quite easily with a fine needle, which we cannot expect in an overprinted fiber picture.

Now we come to a question of conscience: is such a recognition attempt useful in a particular case or should other investigation methods -- without any manipulation of the investigation object -- be preferred?

If, in the case of embeddings, we are to test whether they consist of metal or not, X-rays would seem to be of further help; here we might have to watch out lest we run into possibly present heavy-metal salts. But this is up to the crime detection scientists.

(g) Air, Water, and Liquid Permeability of Paper

These testing methods are used more rarely in crime detection but the attainable measurement values — and we have special devices for this — can give us differentiations which we often can hardly expect.

(h) Absorbency

This test is also used rarely. Besides, it presupposed a corresponding quantity of material.

(i) Glueing Degree

This test — if it is to give us really good comparison values — must be made with a special device.

(j) Ultraviolet Fluorescence of Paper

We obviously do not need to explain further that paper whose material composition differs, must also reveal a differing ultraviolet fluorescence. But it happens that materially identical though otherwise different paper reveals the same fluorescence. Furthermore, we may have a case in which two materially identical types of paper give us differing ultraviolet fluorescence values due to certain reasons (influences). This may have been caused by mere sunlight without the sun effect having to lead to a yellowing of the paper. One of the two papers however may also have been subjected to the effect of certain fumes (e.g., acid fumes), which resulted in a change in the fluorescence.

Therefore ultraviolet analysis has limited value and is partly even unreliable especially in paper examinations.

In this connection one might also think of photography with reflected ultraviolet rays as recognition means, but in view of the multitude of other methods and means, it is used only rarely.

Last but not least, let us point out that the ultraviolet rays are a very important and indispensable aid in the discovery and identification of latent though fluorescent materials which were built into a paper as security components.

(k) Infrared Absorption or Reflection

By the paper to be examined or compared. This method however must be applied only by an expert, at any rate as far as the evaluation of the photographically obtained results is concerned.

The third group (material composition) includes the following.

(a) Qualitative and Quantitative Analysis of the Fiber Material

To recognize the type of fiber, we need to pretreat the paper chemically. The paper is freed of the disturbing auxiliary materials through boiling and is then beaten [defibered] in a colloid mill. The fiber material, which has been exposed and cleansed in this manner, is then treated with special reagents, which gives us a specific fiber coloration.

One of the easiest methods of fiber identification is that of mechanical wood pulp. Wood-containing paper — depending on the quantity portion of lignified fibers — is dyed more or less red by the phloroglucin-hydrochloric acid at the place of application. (Anilin sulfate would give us a yellow coloration.)

The quantitative analysis is performed through counting in the preparation.

The fiber examination and the fiber structure determination will be very informative especially in the case of safety papers. Let us recall that the qualitative and quantitative choice in the composition of the fiber raw material can constitute not only the designation of a certain safety paper, but can also be a noteworthy protection factor due to the limited availability of these materials. In this connection, we must also think of the grinding grade.

(b) Glue Test

This examination is chemical-analytical in nature. (Let us not confuse it with the earlier mentioned testing of the glueing degree.) It is clear that both vegetable and animal glue can be varied by the chemist in so many ways that one can, as a result, obtain not only certain identity characteristics for various papers, but also certain factors which will make it difficult to imitate a safety paper.

(c) Analysis of Fillers

The fillers can be examined purely chemically and also spectro-analytically. We said before that they too play an important role in the production of safety paper.

(d) Dyes

The dyes of dyed papers are examined mostly by chemical analysis. The great role they play above all in protection techniques has been mentioned earlier. Let us recall here especially the (color) indicators which one can find and verify with the help of (chemical) detectors if they are latent.

(e) Ash Picture

Those components of paper which remain behind as incombustible after burning and/or subsequent glowing are called ash. Ash contains the inorganic compounds of paper and is given in percent.

If the fillers are to be identified and determined as to their percentage content with the help of ash, we can do this according to the methods mentioned under (c).

This just about winds up the enumeration of the most important and most frequently used examination methods for the "inborn" characteristics of paper.

As we probably brought out in this article so far, most of the "inborn" characteristics of paper -- partially or totally -- are also at the same time crime detection key elements. There should actually be no need for any further amplification on this here. But we think that a very illustrative example will help make everything we have said so far even clearer.

Let us assume the case of an "artificial" water mark which is supposed to simulate a "genuine" (authentic) water mark. This "artificial" (false) water mark, which came out quite well and deceptively genuine-looking, has been prepared, let us say, by means of embossing plates. It has now become a key element; first of all, it tells us that it is an "artificial" (embossed) water mark and hence a forgery (from which we can in most cases deduce the falsity of its carrier, respectively, paper), and second, it gives us possibly some further investigation clues, telling us where the water mark embossing was performed.

The knowledge about the possibilities of the discussed investigation methods and their handling, coupled with the information on the origin of paper, will help us in our endeavor to take the crime detection key elements from the paper in the particular case at hand.

VI. APPENDIX

In conclusion, let us say the following in the interest of a general orientation on the standardization of paper formats.

The German Standards Committee has fixed and standardized paper formats according to the following principle: we have a preferred Series A, and the supplementary series B and C.

The formats in series A have been provided for readymade formats of independent paper sizes (business letter sheets and folios, business forms, magazines, drawings, etc.); those of the supplementary series have been provided for dependent paper sizes (letter envelopes, etc.).

It ought to be mentioned here that the old folio and quarto format has been replaced with the A 4 standard format (DIN/Deutsche Industrie-Norm — German Industrial Standard A 4).

We must not overlook the fact that the formats of the German Standards Committee coincide with those of the Netherlands, Belgium, Norway, Finland, Austria, Russia, Poland, Switzerland, Czechoslovakia, and Hungary.

The format sizes (in mm) of the individual series are subdivided as follows.

Item	Series A	Series B	Series C
Quadruple sheet	A 0 = 841 x 1189	B 0 = 1000 x 1414	C 0= 917 x 1297
Double sheet	A 1 = 594 x 841	B 1 = 707 x 1000	C 1 = 648 x 917
Sheet	A 2 = 420 x 594	B 2 = 500 x 707	C 2 = 458 x 648
Half sheet	A 3 = 297 x 420	B 3 = 353 x 500	C 3 = 324 x 458
Quarter sheet	A 4 = 210 x 297	B 4 = 250 x 353	C 4 = 229 x 324
Leaf	A 5 = 148 x 210	B 5 = 176 x 250	C 5 = 162 x 229
Half leaf	A 6 = 105 x 148	B 6 = 125 x 176	C 5 = 114 x 162
Quarter leaf	A 7 = 74 x 105	B 7 = 88 x 125	C 7 = 81 x 114
Eighth leaf	A 8 = 52 x 74	B 8 = 62 x 88	C 8 = 57 x 81
	A 9 = 37 x 52	B 9 = 44 x 62	
	A 10 = 26 x 37	B 10 = 31 x 44	

The format designation is always prefixed with "DIN"; thus, in the case of the quarter sheet, we have "DIN A 4."

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